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WHY WE NEED *TEAM* COGNITION

STEPHEN M. FIORE AND EDUARDO SALAS

Contributors to this volume have addressed a number of issues and questions to provide an overview of the different approaches to team cognition. In this vein, authors have considered the team cognition construct as a process or a product of group interaction. In particular, team cognition can be related to the *process* of information encoding, storage, and retrieval, such that a group *product* emerges (Larson & Christensen, 1993). As this suggests, groups or teams can be considered to be information-processing units (Hinsz, Tindale, & Vollrath, 1997) in a manner analogous to early views of human cognition (e.g., Newell & Simon, 1972). Thus, team cognition can describe a process (e.g., the transmission of team-relevant knowledge) or a product (e.g., shared mental model).

When discussing the state of the shared cognition construct in their brief review of recent literature, Cannon-Bowers and Salas (2001) noted that there are three overarching benefits to this construct. First, it enables researchers to explain the complexity of the phenomena surrounding team process. Second, it may be of use in predicting team performance based on

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the metrics used to explain team processes. Third, these may both be useful in the designing of interventions to help overcome process problems in teams. Fitting within this perspective, the contributors to this volume represent researchers who use this construct with one or more of these goals. Our objective with this chapter is not to summarize this work presented by our contributors. Rather we choose to discuss their work in the context of some of the broader themes and issues associated with the team cognition construct. Our hope is that this serves not to provide a conclusion to this volume but to stimulate additional thinking on where the field must go if we are to fully understand the complexity surrounding inter- and intraindividual cognition.

In concluding chapters of edited volumes, it is not uncommon to find at least some use of metaphors or analogies. It seems authors of such chapters believe that the complex and typically diverse contributions making up an edited volume require either analogies or metaphors to capture or reify the overarching issue(s). Indeed, analogies and metaphors often provide useful insights into the understanding of complex phenomena. We will not break from this tradition as we discuss our points using a number of analogies, some proximal and some distal, to the team cognition construct. Specifically, we first look at what may be the foundational goal of team cognition, but we do so from an analogous situation in neuroscience. We then examine how the contributors to this volume address this goal, and we close with some points on where the field stands and where it appears to be going.

A BINDING PROBLEM

Throughout this volume on *team cognition* we see continuing discussion of the need to understand *team coordination*. Although not always explicitly articulated as such, inherent in these discussions is that the manifestation of team cognition is the seamless execution of coordinated behaviors. Analogous views have existed in one form or another throughout the latter half of the 20th century. For example, in early research for the military Glaser (1958) noted how process variables such as anticipatory cuing and sequence predictability could facilitate team coordination. These early constructs described the degree to which patterns of behaviors are cued by fellow member actions and "warn" team members when and how to respond (Glaser, 1958). In his seminal work on group productivity, Steiner (1972) noted that coordination decrements resulted in teams often performing below their full potential, a phenomenon he termed *process loss*. These process losses occurred for any number of reasons, ranging from diminished motivation to distinct compositions to the interdependence of the task (Steiner, 1972). Although much research has been conducted to address this issue, coordination and attempts to reduce coordination decrement remain important issues. Based on the consistent appearance of this coordination goal, one could reasonably argue

that team coordination is the de facto goal of team cognition. This is a deceptively simple point, but a point that gets to the core of understanding team cognition. Specifically, how does *team cognition* lead to *team coordination*; that is, how does the manifestation of cognition in teams eventually result in a coordinated entity in and of itself?

As mentioned, analogies are often helpful in illustrating complex issues and can sometimes provide useful insights into one's understanding (see Schooler, Fallshore, & Fiore, 1995). To understand the complexity of this relation between team cognition and team coordination, consider the following analogy from what has been one of the more perplexing issues in cognitive neuroscience. Here we compare the myriad team processes and products and the assumed coalescence of these, to what is known as the *binding problem* in theories of consciousness. Given that this volume emphasized team cognition, we felt it appropriate to argue that, from a conceptual standpoint, team coordination is analogous to the binding problem. Just as organization theorists attempt to determine how human, communication, and even computer systems cooperate to produce a coordinated entity (i.e., a team), neuroscientists attempt to understand how the variety of sensory channels monitored by the brain coalesce to produce conscious experience.

Consider an example of the binding problem with respect to the perception of a moving object. In such objects,

> the color, shape, and movement are located in one object, whereas the brain events supporting these different facets are apparently located in three different loci. Even if there is synchrony between the neurons in these three different areas, how does this synchrony generate the unified phenomenal object? (Smythies, 1999, p. 164; see also Treisman, 1996)

In trying to understand the complex relation among the input of individual team members, team processes, and team performance, we are asking an analogous question. How do the skills of the team members, the roles they must perform, and the communication strategies they use result in coordinated action?

The binding *problem* with respect to consciousness is sometimes answered by theorizing a binding *mechanism*, a neural mechanism that acts to fuse relevant information into a functional entity (von der Malsburg, 1995). A heavily researched theoretical account for a binding mechanism focuses on synchrony in neuronal firing, in which "binding is achieved by synchronized activity of cells responding to different properties of the same object" (Treisman, 1996, p. 174). When trying to understand team process, many of the contributors to this volume are implicitly theorizing that team cognition may be the mechanism that fuses the multiple inputs of a team into its own functional entity. Further, the notion of "synchronized" neural firing from theories of consciousness certainly resonates with the way we characterize coordinated team performance; that is, exceptional team performance is ex-

emplified by the synchronized actions of the individual members. Thus, whereas neuroscientists attempt to ascertain what is the relation between the brain and consciousness, we attempt to address what is the relation between team cognition and team coordination.

In some of the early writings on what is now called team cognition, theoreticians boldly spoke of notions such as a *team mind* or *collective mind* (e.g., Thordsen & Klein, 1989; Weick & Roberts, 1993) and even made explicit linkages to notions of team consciousness. These analogies provided a helpful starting point to help us conceptualize the complex interaction of a team. What was then required was for the cognitive components, that is, the components being *bound* to produce the coordinated entity, to be specified in such a way that we could begin to both articulate and measure the factors driving team coordination. By framing the research this way, we can better illustrate how the theories, methods, and data discussed in this volume have led to a fuller understanding of team cognition and thus team coordination. For example, researchers in this volume apply terminology such as *awareness* or *metacognition*, constructs that have been applied to describe the phenomenology associated with consciousness (see Cohen & Schooler, 1997). Importantly, though, the researchers in this volume operationalize their constructs in such a way that validation by means of empirical tests is feasible. As such, criticisms levied against similar constructs in consciousness research (see Simon, 1997) are less tenable in the context of team cognition.

In short, cognitive neuroscience has made significant strides in understanding the variety of events potentially making up conscious experiences. Similarly, organizational psychology has made substantial progress in delineating the subfactors of effective teamwork. But, what is less well known in both disciplines is how these subcomponents are bound. When viewing team cognition as the binding mechanism that produces coordinated behavior, we can then discuss the operationalizations of the components of team cognition, and in the next section we consider contributions from this volume within the context of some of the broader themes occurring across chapters.

THE TEAM COGNITION PUZZLE

Continuing with our use of metaphors, understanding this relation between team cognition and team coordination and the differing approaches in this field is like fitting together pieces of a puzzle. The contributors to this volume each have pieces of the puzzle to understanding the relation between team cognition and team coordination. One might argue that the contributors are not working on the same puzzle, but that is debatable. Specifically, the puzzle itself is always team coordination, whether it be coordinating to solve a problem or to make a decision, and the pieces are the team cognition constructs leading to it, whether they be mental models, metacognition, or mutual awareness.

Within this volume there are two distinct themes with respect to the overarching views of team cognition and how contributors are operationalizing these constructs. The conceptualizations can be loosely categorized as fitting under a general theme of *awareness* or *communication*. More specifically, the contributors to this volume view team cognition as a form of awareness that binds the actions of the team or view team communication (both implicit and explicit) as the manner in which team cognition is developed or scaffolded such that coordination results.

This relation among awareness, communication, and team cognition fits well within our analogy to consciousness. The distinction between aware and not aware is often used to distinguish conscious from nonconscious processes in that being able to articulate (i.e., communicate) the nature of this awareness is sometimes a metric used to disentangle consciousness (see Cohen & Schooler, 1997). Some have argued that stringently linking awareness with the ability to articulate this awareness as a metric for consciousness is not necessarily an accurate portrayal of the phenomenology associated with consciousness. Specifically, Schooler and Fiore (1997) noted that content reportability and subjective awareness are not fully overlapping categories in that one is not always able to report something of which one is fully aware (e.g., Schooler, Fiore, & Brandimonte, 1997).

We can make a similar argument for team cognition in that the theorizing of Schooler and Fiore (1997) supports distinctions made between explicit and implicit team coordination. Researchers in team performance describe implicit team coordination not as occurring in the absence of conscious awareness but rather as occurring in the absence of explicit articulation (see Entin & Serfaty, 1999; Fiore, Salas, & Cannon-Bowers, 2001; Fiore, Salas, Cuevas, & Bowers, 2003). Because implicit coordination is often used to describe coordination without explicit communication, it is often used as a proxy measure for the level of shared awareness within a team (see, e.g., Entin & Serfaty, 1999). Thus, implicit coordination in the context of teams may indeed be something of which the team is *aware*, but not something they have articulated. We next use the two themes of awareness and communication in a brief discussion of the pieces to the team cognition puzzle presented in this volume. What is important to note across these contributions is the careful articulation of the operationalization of these constructs.

Theme One: Team Cognition as Shared Awareness

Within the broader theme of team cognition as awareness, Hinsz (chap. 3, this volume) discussed a particular form of awareness within the team task. He showed how adapting the construct of metacognition and considering it within the mental model framework assist not only in understanding team processes but also in providing an avenue with which to measure certain aspects of team cognition. By exploring the ways in which a group processes

information associated with the group's beliefs, Hinsz illuminated the accuracies and inaccuracies associated with components of metacognitive awareness within a group. These findings are important particularly because they show how deconstruction of cognitive components associated with group process can highlight areas associated with process problems. To the degree that these are problems critical to team performance, they can be translated to team training interventions. Further, Hinsz's linking of the belief association matrix to the mental model construct provides an important method of quantification, what Hinsz described as a "model" of mental models. Such methods represent critical steps in our attempts to operationalize constructs associated with what could be amorphous notions of awareness.

By blending cognitive and social approaches, Rentsch and Woehr (chap. 2, this volume) illustrated a unique component to the theme of team cognition as awareness. First, their notion of awareness of teammates' knowledge, in addition to overlap in teammate knowledge, provides an important addition to conceptualizations of team cognition. Similar to theorizing on transactive memory systems (e.g., Liang, Moreland, & Argote, 1995; Moreland & Argote, 2003; Moreland & Myaskovsky, 2000), this component of awareness has to do with perceptions of "who knows what." By taking into account one's perspective on a teammate's knowledge, researchers may be better able to predict how sharedness relates to performance. Furthermore, Rentsch and Woehr's adaptation of social relations modeling to team member schemas uniquely approaches team cognition from the standpoint of person perception and shared cognition (see also Fiore et al., 2001). Second, these methods provide a fruitful avenue with which one can understand team process and performance. Akin to techniques adapted by Hinsz, the melding of these approaches lends strength to our understanding of teams by allowing more quantitative models and methods to measure the awareness component of team cognition.

The pioneering work of Gutwin and Greenberg (chap. 9, this volume) in the area of computer-supported collaborative work has been instrumental to our understanding of how it is that awareness is foundational to team cognition. Their systematic development of systems to support teamwork has led to an elegant articulation of some of the most critical issues surrounding team cognition in distributed work. An intriguing aspect of their framework involves the utility of the common-ground construct arising out of communications research and psycholinguistics (e.g., Fussell & Krauss, 1989). Gutwin and Greenberg used common ground from two converging points: visual and conversational. Their work shows how converging approaches to scaffold-distributed interaction facilitates awareness through social cognitive processes of visual and conversational (i.e., communications based) common ground. Further, the operationalization of system design factors that support "embodiments" and similar "expressive artifacts" most certainly provides the visual cues necessary to support team cognition. Indeed, these tech-

niques can surmount limitations associated with distributed work arising from *team opacity*, the experience of increased ambiguity and artificiality associated with distributed interaction that can hinder mutual awareness (see Fiore et al., 2003).

Fiore and Schooler (chap. 7, this volume) similarly argued for the foundational nature of mutual awareness in driving team cognition and coordination. They noted that team cognition in the context of problem solving hinges on shared awareness of the problem that can be developed through facilitated communication. They illustrated the degree to which process mapping techniques scaffold shared problem models that drive effective process and performance. Fiore and Schooler noted that the process mapping technique forces the individual team members to articulate their conceptualization of the problem. This increases the level of awareness for a given problem and illustrates how communication in problem-solving teams drives the level of shared cognition experienced.

Theme Two: Team Cognition and Team Communication

Cooke, Salas, Kiekel, and Bell (chap. 5, this volume) argued how it is that team processes such as communication can produce effective team knowledge. Using the term *holistic knowledge*, they described how individual cognitive components are integrated through team processes such as communication to produce team cognition. This is essentially team cognition emerging as a result of team interaction "sharpening" individual cognition into a well-sculpted "whole" product. Furthermore, Cooke et al. illustrated how techniques used in cognitive psychology can be adapted to assist in capturing analogous processes in teams. Associative thought has long been analyzed in cognitive psychology using techniques devised to tap semantic linkages (e.g., in studies of priming and memory). Cooke et al. used variants of such methodologies to ascertain the degree to which team members similarly view team-related knowledge. Finally, they described exciting emerging techniques that may be able to capture cognition more dynamically. They showed how coding schemes can be developed to ascertain higher level cognition within a team (e.g., a team's overall understanding of a situation). In particular, they used communication protocols as a *window to team cognition* and argued that if "teams are to be the unit of analysis under our holistic definition, we will need to measure behaviors exhibited by the team as a whole." Protocol analyses have a long history in cognitive psychology (e.g., Chi, de Leeuw, Chiu, & Lavancher, 1994; Ericsson & Simon, 1993), but, by using techniques adapted from methodologies developed for assessing comprehension (e.g., latent semantic analysis; see Foltz, Kintsch, & Landauer, 1998), Cooke et al. paved the way for online assessment of communication and comprehension processes in team cognition. As such, these forms of systematic and rigorous

methods of analyzing the team communications supporting team cognition represent important contributions to the field.

Within the broad theme of team cognition and team communication, Levine and Choi (chap. 8, this volume) illustrated how changes in team membership alter the nature of the discussion to include more strategy-relevant messages. They suggested that teams experiencing turnover as well as those performing more poorly are more likely to try to revise or reiterate what is, or what should be, the shared cognition as they attempt to ensure a mutual understanding of the task. Thus, teams try to alter the nature of their shared cognition when they are *aware* that their performance is suffering or when there may be a disruption to the level of sharedness (i.e., during membership change). Their analyses of team communication protocols illustrated how turnover affects this awareness; they further noted that understanding how the process of team cognition is altered is a critical and open area of research.

Relating communication to team cognition is at the core of the chapter by MacMillan, Entin, and Serfaty (chap. 4, this volume). They described how it is that communication can be altered by task and team structure factors and can affect level of awareness of the team members. What is noteworthy is that they attempted to scaffold team cognition through their structural manipulations such that communication is reduced while level of awareness is either facilitated or not negatively affected. Specifically, MacMillan et al. illustrated how the deleterious consequences of *communication overhead* can be attenuated with manipulations of organizational structure. They additionally highlighted the beneficial effects of mission planning whereby reflective activity prior to interaction facilitates coordination. These findings are analogous to studies of expert problem solving in which research documents that experts in a particular field spend a considerable amount of time representing a problem before attempting to solve it (e.g., Chi, Glaser, & Rees, 1982). Thus, teams given the opportunity to engage in preprocess coordination (see Fiore et al., 2003) illustrate how preparatory behaviors such as planning can facilitate later coordinative efforts. These activities increase mutual organizational awareness and assist by developing shared task representations.

Sycara and Lewis's (chap. 10, this volume) application of theories of team performance to intelligent agents research similarly fits within both of our thematic approaches to team cognition. One could argue that these agents support team member awareness such that team cognition is scaffolded at multiple levels. In these instances cognitive activity formerly managed by varying team roles is offloaded to intelligent agent technology. These agents are programmed to engage in both lower level (e.g., information gathering) and higher level (planning) information-processing activities so as to facilitate team-level awareness that supports coordination within a team. The agents, then, may decrease the communication demands formerly tied to particular team members (because these tasks are now automated). Like

MacMillan et al., then, Sycara and Lewis showed the apparent paradoxical effects of increases in awareness along with decreases in communication.

By identifying what are labeled implicit and explicit coordination mechanisms, Espinosa, Lerch, and Kraut (chap. 6, this volume) showed how a task-analytic approach can illuminate team cognition. Indeed, their work represents an important addition to the long history of psychological research into task factors, process, and performance (e.g., in cognitive psychology, Reitman, 1965; Simon, 1973; Voss & Post, 1988; in social psychology, McGrath, 1984; Steiner, 1972). Like Gutwin and Greenberg, Espinosa et al. took their investigation of how tasks affect group process and performance into the realm of distributed teams and added a new layer of context to this area. Their articulation of the importance of *task dependencies* and related antecedents shows how communication and subsequent coordination can be altered. Further, their distinctions for implicit and explicit coordination mechanisms help to formalize the connections among, for example, team communication, shared mental models, and group outputs and fit within our conceptualization of team cognition as a means of binding member inputs.

Summary

In this section we have discussed how contributors to this volume have used the team cognition construct to help readers understand how communication and awareness result in the coordinated actions of the individuals composing a team. Given our analogy to consciousness, it behooves us to levy the following query of the team cognition construct, a query often levied against the construct of consciousness. Specifically, is team cognition an epiphenomenon, in that it is merely an *additive* process/product associated with multiple members, or is it truly a *synergistic* process/product? Within consciousness studies, this question can be considered more rhetorical as it relates to attempts to theorize about such a complex issue. But, such a question may indeed be more appropriate for team cognition researchers in that considerable resources are brought to bear with the implementation of teams in organizations. That is, the consequences of understanding team cognition have a more immediate societal impact than the consequences of understanding consciousness. More specifically, the field must address the positive (i.e., synergistic) aspects of team cognition as well as the negative (i.e., inhibitory) aspects of team cognition. Organizational and social psychologists have been addressing the negative consequences of group interaction for a number of years (e.g., Hackman, 1998; Hastie, 1986; Janis, 1972; Stroebe & Diehl, 1994), and for the field to mature we must continually ask whether the byproducts of team cognition are always beneficial or whether there are times when they may be inhibitory. As such, from both the laboratory and from the field, we must better specify the functional and dysfunctional aspects of team cognition as we fit the pieces of this puzzle together.

Related to this, the field must better address to what degree team cognition is a process associated with interaction or whether it is a product resulting from interaction. This issue is reminiscent of problems surrounding the construct of situation awareness in military research in which the distinction is sometimes made between situation awareness and situation assessment (e.g., Salas, Cannon-Bowers, Fiore, & Stout, 2001). Situation *assessment* is the term used to describe the processes (e.g., attention, pattern recognition, communication) that are engaged to produce the end product of situation *awareness*. Approaches to this issue can vary whereby some frame their research around training situation assessment processes, whereas others measure outcomes by assessing situation awareness levels (see McNeese, Salas, & Endsley, 2001). Similarly, in team cognition, addressing this distinction depends on the level of analysis chosen by the researcher. Some frame their questions around consideration of a process of team cognition such as implicit strategies for coordination, whereas others consider team cognition to be a product resulting from this interaction (e.g., a shared mental model).

The preceding discussion shows how, metaphorically, team cognition can be like a field-dependence task, where it may be the figure or it may be the ground. What may be required to integrate approaches, then, is a multilevel theoretical approach. In such approaches researchers theorize about multiple levels of analysis (e.g., individuals, groups, and organizations) to better specify how they are conceptualizing construct(s) that can cut across levels (see Klein & Kozlowski, 2000). Theoretical models with a multilevel approach can take on differing forms, for example, a "cross-level model in which higher-level variables are hypothesized to moderate the relationship of two or more lower-level variables . . . [or] models focused . . . on the role of the individuals in shaping the organizational context" (Klein, Cannella, & Tosi, 1999, p. 246). By not taking a multilevel approach, some suggest that one could not only miss relationships but also inaccurately specify the relations they are attempting to address (see discussions in Klein & Kozlowski, 2000). A number of contributors to this volume have presented theories or frameworks that begin to meet some of the criteria for a multilevel theoretical model. The development of such models for team cognition may be an important step forward if they can specifically formulate an integration of cognitive processes and cognitive products within teams so that empirically testable principles can be derived.

TEAM COGNITION DEVELOPMENT

We began this volume by asking and answering the question "Why *team* cognition?" At the conclusion of this volume, we would like to revisit this question and more specifically ask (and answer), "Do we need the construct of *team cognition*?" As one might expect, we believe the answer to this

question is yes, and we have discussed the value added by the team cognition construct. To add to this, we note that progress in science typically occurs when disciplines begin to adopt and adapt theoretical and empirically derived principles from tangential disciplines (see Dunbar, 1995, 1997). Further, the bond between disciplines is strengthened by the use of techniques that have consistently documented predictive utility in other domains. Perhaps we can more cogently state that the contribution the construct makes is as an organizing framework rather than an end to itself (see Cannon-Bowers & Salas, 2001). Team research has progressed in important ways because constructs coming out of cognitive psychology have been applied and adapted to aid our understanding of team process and performance. For example, the mental model construct has been used for over 10 years to drive a number of productive research efforts. Indeed its influence is still felt as a number of chapters in this volume rely on the mental model construct to elucidate team process and performance. Nonetheless, the message of this chapter is that the adoption is only useful if these constructs are operationalized such that they provide meaningful methodologies and empirical tests to validate their utility.

As the chapters in this volume document, many efforts are addressing problems with operationalization and measurement, and the theories are becoming more sophisticated, further illustrating the increasing maturity of the field. To use our final metaphor, we can then ask at what stage of *development* is the field of team cognition. Metaphorically, it is probably safe to characterize the final decade of the 20th century as something similar to early and middle childhood for the team cognition construct. We mean not to be disparaging, rather we wish to illustrate that much like in the early years of childhood, we have seen not only rapid growth but also a building of vocabulary (i.e., terminology) and a building of competencies (i.e., methodologies).

As for the current state of the field, it is more akin to adolescence as the vocabulary and competencies are beginning to coalesce and we are more confident in testing ourselves. For example, only in the last few years has the field shifted from being primarily theoretically based to now also being empirically based. Again, this is not meant to be critical commentary, only a characterization of where we are, and how far we need to go. Although the field's level of maturity is still low, it is beginning to express some independence, not only from organizational psychology but also from cognitive psychology. This independence, while still somewhat awkward, does suggest where the field must now go—a real shift from what previously could be characterized as multidisciplinary to what may be truly interdisciplinary. Social and literary critic Roland Barthes noted an important distinction between these ideas: "To do something interdisciplinary it's not enough to choose a 'subject' (a theme) and gather around it two or three sciences. Interdisciplinarity consists in creating a new object that belongs to no one"

(Roland Barthes in *Jeunes Chercheurs*, quoted from Clifford & Marcus, 1986, p. 1). Thus, rather than adapting the vocabulary of other disciplines, for team cognition to reach its next developmental stage, what may be necessary is the creation of a truly independent discipline in which the old disciplines have dissolved for the sake of a new language and a new object (Barthes, 1977).

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